R&D Towards a Low Energy Solar Neutrino Detector

K.T. Lesko and A.W. Poon

Recently SNO solved the solar neutrino problem[1, 2], in a single experiment observing flavor changing ν oscillations, and significantly constraining the matter-enhanced oscillation parameters. KamLAND[3] has demonstrated a ν deficit consistent with the LMA solution favored by the solar ν experiments. From these experiments and assuming CPT conservation, we conclude neutrinos are massive, the Δm^2 is small and the θ_{12} is large and non-maximal. To address the questions of ν oscillations and fundamental symmetries within the neutrino sector we require precise determinations of the mixing parameters, in particular the solar mixing angle to understand the MNS mixing matrix. Uncertainties remain in the number of neutrino families and one experiment and several models suggest the existence of sterile ν's. Having shown physics beyond the standard model - ν mass and mixing, we are defining the full nature of ν. We will develop a solar ν experiment with sensitivity to p-p neutrinos. The measurement of low energy neutrinos will permit us to obtain crucial information on neutrino oscillations and the determination of mixing angles. These neutrinos will also enable a careful test of solar models and tests of the unitarity of the MNS neutrino oscillation matrix. In order to measure low energy neutrinos new technologies, advanced detectors, and special laboratory environments are required. Coupled to the solar neutrino work, double beta decay provides the best opportunities to determine if νs are Dirac or Majorana and establish the mass scale.

We will leverage NSDs experience in neutrino research and detector development and computer resources. We propose the use of super-fluid helium as a detector medium for low energy solar νs. Initially this involves Monte Carlo investigations into intrinsic and cosmogenic backgrounds and the production of optimum detector configurations, shielding media, construction materials, and fabrication techniques. We established an informal collaboration with Brown University and established a baseline design for the detector. This will involve R&D into detector read-out and signal processing as well as improving our Monte Carlo models and background estimates. These efforts build on the efforts at Brown University in phonons and scintillation detection. In subsequent years we will develop detector prototypes to be deployed at a deep underground site. Coupled to these efforts we propose developing a low background counting facility to be used in the preparation of both the low energy solar neutrino project as well as directly applicable to near term double beta decay experiments.

A baseline engineering concept has been developed and is presented in Fig. 1.

We are continuing our development of Monte Carlo simulations of background signals in this detector, concentrating on intrinsic contamination of the detector materials, and in developing refined signal detector schemes for the active detector region.

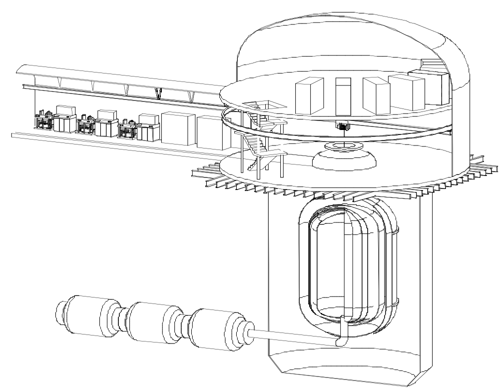

FIG. 1: Our baseline engineering drawing of a low energy p-p solar neutrino experiment based on superfluid Helium.

[1] Q.R. Ahmad *et al.*, Phys. Rev. Lett. **87**, 071301 (2001).
[2] Q.R. Ahmad *et al.*, Phys. Rev. Lett. **89**, 011301 (2002).
[3] K. Eguchi *et al.*, Phys. Rev. Lett. **90**, 021802 (2003).